

Flexible Pavement Analysis on the Banjaran–Pangalengan Road, Bandung Regency Using the 2024 Manual for Pavement Design (MDP)

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Abstract

The Banjaran–Pangalengan Road is a collector road that connects Banjaran District to Pangalengan District, with a total length of 19.67 kilometers. The objective of this study is to analyze the required thickness of flexible pavement along this road segment using the 2024 Bina Marga Manual for Pavement Design (MDP). The MDP 2024 method was applied as the basis for determining pavement layer thickness in accordance with updated national design standards. The data used in this research were traffic volume data for the Banjaran–Pangalengan Road. Based on the analysis results, the designed flexible pavement includes an aggregate base course with *Thus*, the pavement thickness design for the Banjaran–Pangalengan road segment resulted in an AC-WC thickness of 40 mm, an AC-BC thickness of 75 mm, and an AC-Base thickness of 100 mm.

Keywords : Banjaran-Pangalengan road, MDP 2024, Flexible Pavement

1. INTRODUCTION

Pavement design plays a critical role in ensuring the structural integrity, functionality, and long-term performance of road infrastructure. In recent years, the shift from purely empirical approaches toward mechanistic-empirical (M-E) design frameworks has gained traction globally, driven by the need for more accurate performance predictions and optimized material utilization. Mechanistic-empirical methods integrate fundamental engineering principles with field-calibrated empirical data, allowing for a more comprehensive consideration of traffic loads, environmental conditions, and material behaviors.

This study aims to analyze the structure and application of MDP 2024 within the context of flexible pavement design. By implementing the method on a representative road segment and comparing the design outcomes with those of previous approaches, the research seeks to evaluate the benefits, challenges, and practical implications of transitioning toward a mechanistic-empirical design paradigm in Indonesia. The findings are expected to contribute to the refinement of national design standards and support the development of more resilient and economically efficient pavement systems.

1.1. MDP 2024

MDP 2024 replaces the 2017 edition in order to harmonize the Pavement Design Method (MDP) with the *General Specifications for Road and Bridge Works*, and to integrate several technical guidelines related to pavement design and planning, pavement preservation strategies considering subgrade bearing capacity, as well as updated parameters for local material characteristics. MDP 2024 adopts a mechanistic-empirical approach for flexible pavement design, with its primary output presented in the form of a structural catalogue.

MDP 2024 adopts a mechanistic-empirical approach to flexible pavement design, in line with international best practices such as the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG). This dual approach combines analytical modeling of pavement responses—such as stresses, strains, and deflections—with empirical calibration based on long-term performance data. The method enables a more accurate assessment of pavement lifespan and deterioration behavior under specific traffic loads and environmental influences, enhancing the reliability of design outputs.

1.2. Flexible Pavement

Flexible pavement is a multilayered road structure designed to distribute traffic loads gradually from the surface to the subgrade. It consists of asphalt surfacing, base, subbase, and subgrade layers, where each layer plays a role in load attenuation. In contrast to rigid pavements, flexible pavements deform elastically under loading and rely heavily on the mechanical properties and thicknesses of each component layer. Their structural performance is

influenced by factors such as traffic intensity, environmental conditions, moisture variation, and the mechanical strength of the materials used.

In MDP 2024, flexible pavement design follows a mechanistic-empirical framework that evaluates pavement responses such as tensile strain at the bottom of the asphalt layer and compressive strain on the subgrade. These responses are linked to fatigue and rutting criteria, which serve as performance indicators over the pavement’s design life. The design is further supported by regional material properties, climate zone classification, and axle load spectra typical of Indonesian roads. This integrated approach allows for more context-sensitive pavement solutions that are both structurally reliable and economically sustainable.

1.2.1. Lapisan perkerasan lentur

The Asphalt Concrete – Wearing Course (AC-WC) is a type of asphalt concrete layer, similar to AC-BC (Binder Course) and AC-Base, that is specifically positioned as the uppermost layer of the pavement structure. It functions as the surface or wearing layer and must provide a smooth finish to ensure safety and comfort for road users. This layer is required to have a high level of surface roughness to maintain adequate skid resistance, as it is the layer directly in contact with vehicle tires.

The Asphalt Concrete – Binder Course (AC-BC) is a pavement layer positioned above the asphalt base course and below the asphalt wearing course. The AC-BC layer functions to transfer traffic loads it receives to the underlying base course and subsequently to the lower pavement layers. Although the AC-BC layer is not directly exposed to weather conditions, it must possess sufficient thickness and stiffness to prevent stress or strain caused by traffic loads from being transmitted excessively to the base and subgrade layers. The performance of the AC-BC mixture is primarily characterized by its stability value.

Asphalt Concrete – Base is a pavement layer positioned below the Asphalt Concrete – Wearing Course (AC-WC) and the Binder Course (AC-BC), and above the subbase layer. This layer functions to support and receive vehicular loads transmitted from the upper layers, and subsequently distribute them to the lower layer, namely the subbase

2. METHOD

The method used in this study is a quantitative descriptive research method, which aims to systematically and measurably describe phenomena or characteristics of the population or object under study using quantitative data. This approach is employed because the research utilizes traffic data collected from the Banjaran–Pangalengan road segment.

2.1. Data Analysis Technique

The data analysis technique in this study was carried out using Microsoft Excel software to perform the pavement design calculations based on the MDP 2024 method.

3. Results and Discussion

In this study, the pavement thickness design was carried out for the Banjaran–Pangalengan road segment in West Java using the 2022 Pavement Design Manual (Manual Desain Perkerasan 2022). The design was based on a planned service life (design life) of 20 years and a construction period of 2 years.

Table 1: 2022 LHR Data

Class	Types of Vehicle	LHR 2022
1	sepeda motor	15245
2	sedan	3281
3	angkutan umum sedang	1137
4	pick up	1365
5a	bus kecil	98
5b	bus besar	61
6a	truk ringan 2 sumbu	297
6b	truk sedang 2 sumbu	629
8	kendaraan tak bermotor	17

In accordance with the provisions of the 2024 Pavement Design Manual (Manual Desain Perkerasan 2024), the traffic growth factor is predetermined within the method based on planning requirements. For the purpose of this study, a traffic growth factor of 3.5% was applied. This growth factor is used to determine the cumulative

multiplication factor for calculating the Average Daily Traffic (ADT) during the 2-year construction period, which based on the MDP 2024 guidelines was determined to be 1.07.

The design lane refers to the traffic lane within a road segment that carries the highest volume of commercial vehicles (trucks and buses). The traffic load on the design lane is expressed in terms of cumulative Equivalent Standard Axle Loads (ESAL), taking into account the Direction Distribution Factor (DD) and the Lane Distribution Factor (DL). In this study, the values used for DD and DL are 0.5 and 0.8, respectively, based on the 2024 Pavement Design Manual (MDP 2024) for roads with two lanes in each direction.

The Equivalent Load Factor or Vehicle Damage Factor (VDF) of a specific vehicle refers to the total ESA (Equivalent Standard Axle) load value from all axle groups of that vehicle. The VDF used in this study is based on West Java's regional VDF data, corresponding to the selected road segment. The Cumulative Equivalent Standard Axle Load (CESAL) represents the total cumulative design traffic axle load on the design lane over the planned service life. Based on a design life of 20 years and an annual traffic growth rate of 3.5%, the calculated CESAL value (R CESAL) in this study is 20.0666.

Table 2: Cesal Calculation Result

Class	Types of Vehicle	LHR 2022	Code	R 2 years	LHR 2024	VDF	DD	DL	R Cesal	CESAL 5
1	sepeda motor	15245	1.1	1.071	16331		0.5	0.8	20.0666	
2	sedan	3281	1.1	1.071	3515		0.5	0.8	20.0666	
3	angkutan umum sedang	1137	1.1	1.071	1218		0.5	0.8	20.0666	
4	pick up	1365	1.1	1.071	1462		0.5	0.8	20.0666	
5a	bus kecil	98	1.2	1.071	105		0.5	0.8	20.0666	
5b	bus besar	61	1.1	1.071	65	1.3	0.5	0.8	20.0666	248875.0722
6a	truk ringan 2 sumbu	297	1.1	1.071	318	0.4	0.5	0.8	20.0666	372841.8484
6b	truk sedang 2 sumbu	629	1.2	1.071	674	5.5	0.5	0.8	20.0666	10857292.71
8	kendaraan tak bermotor	17		1.071	18		0.5	0.8	20.0666	
									CESAL	11479009.64
									CESAL	12x10 ⁶

Based on the results of the CESAL calculation, a total of 11,479,009.64 or approximately 12×10^6 was obtained. Accordingly, the pavement thickness design using the MDP 2024 method is determined as follows:

Beban rencana 20 tahun (10 ⁶ ESA5)	STRUKTUR PERKERASAN								
	FFF(1) 1	FFF(1) 2	FFF(1) 3	FFF(1) 4	FFF(1) 5	FFF(1) 6	FFF(1) 7	FFF(1) 8	FFF(1) 9
	Untuk beban rencana < 30 juta ESA5 menggunakan Aspal Pen				Untuk beban rencana ≥ 30 juta ESA5 direkomendasikan menggunakan Aspal PG70 ⁽¹⁾				
	< 2	> 2 - 5	> 5 - 10	> 10 - 15	> 15 - 30	> 30 - 50	> 50 - 100	> 100 - 150	> 150 - 200
	Tebal Perkerasan (mm)								
AC WC	60 ⁽²⁾	40	40	40	40	40	40	50	40
AC BC	-	65	75	75	60	60	75	80	60
	-	80	80	-	-	-	-	-	-
AC Base ⁽³⁾	-	-	-	100	80	85	100	100	80
	-	-	-	-	80	100	100	100	80
	-	-	-	-	-	-	-	-	90
Lapis Fondasi Agregat Kelas A ⁽⁴⁾	200	200	200	200	200	200	200	200	200
Lapis Fondasi Agregat Kelas B	150	150	150	150	150	150	150	150	150
Timbunan Pilihan Berbutir Kasar atau LFA Kelas C atau Stabilisasi Semen ⁽⁵⁾	-	-	200	200	200	200	200	200	200

Figure 1: Flexible Pavement Structure

Thus, the pavement thickness design for the Banjaran–Pangalengan road segment resulted in an AC-WC thickness of 40 mm, an AC-BC thickness of 75 mm, and an AC-Base thickness of 100 mm

4. Conclusions

The pavement design for the Banjaran–Pangalengan road segment was successfully carried out using the 2024 Pavement Design Manual, incorporating a 3.5% annual traffic growth rate and a 20-year design life. The analysis, which considered regional VDF values, traffic distribution factors (DD = 0.5, DL = 0.8), and a calculated CESAL of approximately 12×10^6 , resulted in a recommended pavement structure consisting of 40 mm AC-WC, 75 mm AC-BC, and 100 mm AC-Base.

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